Phytopathology

Official Organ of the
American Phytopathological Society

CONTENTS

Species of Fusarium isolated from onion roots. . . . Clarence F. Stoneb
Biological and cultural studies of Exoascus deformans. . . . . A. J. Riker
Phyllosticta leaf spot, fruit blotch and canker of the apple, its etiology and control. . . . . E. F. Guba
The production of substances toxic to plants by Penicillium expansum Link. . . . . Otto C. Bridgeford
Phytopathological notes, etc. . . . . Page

Price { $3.00 per year, United States and dependencies, Mexico and Cuba
$3.25 per year, Canada
$3.50 per year, foreign countries

PUBLISHED MONTHLY BY THE SOCIETY
AT THE OFFICE OF PUBLICATION
Queen Anne and Green Streets, Lancaster, Pa.

Entered as second-class matter at the post office at Lancaster, Pa.

SAVE FRUIT, TIME AND MONEY
BY DUSTING

You can protect 5 acres of mature apple trees or 4 acres of field crops per hour.

Get the right NIAGARA for your farm and save ⅔ of the time and labor ordinarily required in fighting insects and diseases. Dust and you can cover all the trees and crops at just the right time—that means real crop protection.

It will pay you to call on the NIAGARA dealer or write and find out just what model Duster and what Dusts are the best to use. Get posted on dusting; our specialists are at your service.

Niagara Sprayer Company
Middleport, New York

Whetzel's Phytopathology

Professor Whetzel divides his work into Eras and Periods. He gives a general survey of each Era and each Period, crystallizes the evolutionary movement of each, gives interesting biographic sketches of the predominant figures, frequently including portraits, and at the end of each Period adds a concise summary.

History of Phytopathology. By Herbert Hice Whetzel, Cornell University. Cloth, $3.00 net.

Fred's Soil Bacteriology

These laboratory exercises are prepared to give *quantitative results* for students of soil bacteriology, chemistry, physics, and plant pathology. You get *practical exercises.*

Soil Bacteriology. By E. B. Fred, Ph.D., University of Wisconsin. Cloth, $1.50 net.

W. B. SAUNDERS COMPANY
West Washington Square Philadelphia

WANTED

Phytopathology, Volumes 2, 3, and 4, part 1 of Volume 9. Offers stating price to the Director, Pathological Laboratory, Road, Harpenden, Herts, England.

Purchase from our advertisers. Mention Phytopathology when ordering.

PHYTOPATHOLOGY

VOLUME XIV NUMER 5

MAY, 1924

SPECIES OF FUSARIUM ISOLATED FROM ONION ROOTS

CHRISTOS P. SIDERIS

WITH PLATES IX TO XI

INTRODUCTION

In a study, on the determination of the causal organism of the pink root disease of onions, different species of Fusarium were isolated from roots showing symptoms of the disease. The morphological behavior of the different species was studied on culture media such as Wollenweber (6, 7) and Sherbakoff (3) used. New culture media, introduced by the writer, were used occasionally for the study of certain characters.

Certain new species and varieties were found among the different organisms. These are described and named. Those of the organisms, however, which have been described and named by previous investigators are given only a short mention in this paper. The writer is indebted to Dr. C. D. Sherbakoff for the determination of many of the organisms listed in this paper and for other very helpful suggestions.

FUSARIA ISOLATED

The different Fusarium species, isolated from onion roots with and without symptoms of the pink root disease, were studied in their morphological characters and physiological behavior in the manner followed by previous investigators. They were found to belong to four sections, *viz.*, Elegans, Discolor, Martiella and Moniliform, and to twenty species and varieties. To those of the organisms whose identity could not be established through the available literature, the writer assigned new names.

The different organisms are segregated in this presentation into two groups: (1) into species described by previous investigators, and (2) new species. Both previously described and new species and varieties are illustrated in plates IX, X and XI.

SPECIES DESCRIBED BY PREVIOUS INVESTIGATORS

Section Elegans

F. oxysporium Scht., (3) Pl. IX; *F. malli* Taub., (5) Pl. IX; *F. redolens* Wr., (3, 7) Pl. IX; *F. lutulatum* Sher., (3) Pl. IX; *F. oxysporium* var.

resupinatum Sher., (3) Pl. IX; *F. oxysporum* var. *longius* Sher., (3) Pl. IX; *F. orthoceras* var. *triseptatum* Wr., (6) Pl. IX; *F. angustum* Sher., (3) Pl. X.

Section Discolor

F. discolor Ap. et Wr., (1, 3) Pl. IX; *F. discolor* var. *sulphureum* Ap. et Wr., (1, 3) Pl. X; *F. culmorum* (W. Smith) Sacc., (3) Pl. X.

Section Martiella

F. radicicola Wr., (3) Pl. X; *F. Martii* Ap. et Wr., (3) Pl. X.

Section Moniliform

F. moniliform Sher., (4) Pl. X.

NEW SPECIES

Section Elegans

Fusarium cromyophthoron n. sp.

Diagnosis.—Conidia (Pl. IX and XI) 3-, 4-, and 5-septate, 3-septate more common, occur in sporodochia or pionnotes, in masses salmon colored; size of 3-septate 37 × 3.25 μ, 4-septate 45 × 3.75 μ and 5-septate 55 × 4 μ. Chlamydospores terminal and intercalated, single and catenulate, size 7 μ in diameter. Sclerotia colorless not reappearing under prolonged cultural conditions. Ascigerous stage unknown.

F. cromyophthoron produces a perfect pinnotal stage and differs slightly from *F. lycopersici* Sacc. in the size of its conidia; in the latter the conidia are longer and the colorless sclerotia are considered as a constant morphological character.

Habitat.—On roots of onions with symptoms of pink root disease and on onion bulbs with powdery rot. Occurs in the Delta district near Stockton, California.

Fusarium rhizochromatistes n. sp.

Diagnosis.—Conidia (Pl. XI) 3-, 4-, 5- and 6-septate, 3-septate more common, occur in sclerotial and plain sporodochia and pseudopionnotes, in masses salmon colored. Chlamydospores terminal and intercalated, single and catenulate, size 7 to 10 μ. Sclerotia 3 to 6 mm. of a brownish blue color at the center of the colony and small bluish 1 to 3 mm. at the margins. Aerial mycelium well developed, hyphae from 5 to 10 mm. long, distinct, not interwoven or forming coremia like structures. Substratum ranging between peach and orange colors. Ascigerous stage unknown.

Habitat.—On roots of onions, Irish potatoes and millet with symptoms of pink root disease. Occurs in the Delta district near Stockton, California.

Fusarium rhizochromatistes var. **microsclerotium** n. v.

Diagnosis.—Conidia (Pl. XI) similar in size and curvature as in *F. rhizochromatistes*. It differs in the size of the sclerotia which measure from 1 to 3 mm. of a bluish color. Sporodochia not emerging from sclerotia.

Habitat.—On roots of onions with symptoms of pink root disease. Occurs in the Delta district near Stockton, California.

Fusarium sclerostromaton n. sp.

Diagnosis.—Conidia (Pl. XI) 3-, 4- and 5-septate, 3-septate more common, other forms rare, occur in sporodochia emerging from a continuous rough plectenchymatic layer covering the entire surface of the colony during the early stages of growth, in masses salmon colored. Chlamydospores terminal and intercalated, single and catenulate, size 7 to 10 μ. Sclerotia growing over the plectenchymatic layer first colorless and later turning bluish, size 1 to 3 mm. Aerial mycelium growing over the plectenchymatic layer in irregular masses, length of hyphae from 3 to 5 mm. interwoven in cottony like masses. Substratum of a grayish peach to grayish orange color, Ascigerous stage unknown.

Habitat.—On roots of onions with symptoms of pink root disease. Occurs in the Delta district near Stockton, California.

Fusarium loncheceras n. sp.

Diagnosis.—Conidia (Pl. XI) 3-, 4-, 5- and 6-septate, 5-septate more common, size of 5-septate 47×3.25 μ, slightly or not arcuate, lanceolate, occur in eupionnotes of honey and orange colors. Chlamydospores terminal and intercalated, the former more common, single and catenulate, size 5 to 8 μ. No sclerotia. Aerial mycelium absent or slightly developed at the margins of the colony. Substratum ranging between peach and orange colors. Ascigerous stage unknown.

F. loncheceras has certain similarities with *F. angustum* Sher., it differs, however, from the latter in the color of its conidia and substratum and in the septation of the conidia in proportion to their size.

Habitat.—On roots of onions with and without symptoms of pink root disease. Occurs in the Delta district near Stockton, California.

Fusarium loncheceras var. **microsporon** n. v.

Diagnosis.—*F. loncheceras* var. **microsporon** (Pl. X) differs from *F. loncheceras* in the size of its pionnotal conidia and the production of a greater number of 3-septate than 5-septate conidia. Substratum of a clayish to brickish color. Pionnotes forming a thinner layer than in *F. loncheceras*. Aerial mycelium absent in carbohydrate media but slightly developed in protein media; hyphae aggregate forming coremia like structures.

Habitat.—On roots of onions with symptoms of pink root disease. Occurs in the Delta district near Stockton, California.

BEHAVIOR OF FUSARIA IN DIFFERENT MEDIA

Culture Media

The methods, employed for the systematic study of the different morphological characters developed by *Fusaria*, consisted in growing the particular organism on different nutrient substances and observe its behavior thereon. The culture media used in these studies were: (1) dextrose agar, (2) dextrose bean agar, (3) potato tuber plugs steamed, (4) steamed Melilotus stems, (5) steamed blackberry stems, (6) steamed rice grains, and (7) beef extract agar.

The first culture medium, dextrose agar, was prepared with addition of 1.75 per cent agar-agar in a solution containing the following: distilled water 1000 c.c., dextrose 20 grms., $MgSO_4$ 2.12 grms., $Ca(NO_3)_2$ 0.71 grms., KH_2PO_4 1.36 grms., and $Fe(NO_3)_3$ 1 c.c. of a 5 per cent solution. Half liter portions of the solution were adjusted to different H-ion concentrations by the addition of appropriate reagents (0.2/N, HCl and KOH) before mixing with the agar. The medium was tubed, after boiling, in test tubes in 20 c.c. portions and sterilized.

The second culture medium, dextrose bean agar, was prepared with the addition of 1.5 per cent agar-agar in a solution containing the following: dextrose 20 grms., and lime bean decoction 1000 c.c. The lima bean decoction was prepared by boiling 200 grams of lima beans in 1000 c.c. of tap water for one hour, then straining the mixture through cheese cloth and retaining the solution.

The third, fourth, fifth a ixth were prepared by adding 5 c.c. of water or more, in the case of ixth, in test tubes containing the vegetable medium and sterilizing.

The seventh, beef extract agar, was prepared in a similar manner as the dextrose agar medium except that dextrose was substituted by 1 per cent beef extract.

INFLUENCE OF THE SUBSTRATUM ON THE DEVELOPMENT OF CHARACTERS

Sherbakoff, Wollenweber and other investigators observed that different media influence the development of characters in Fusaria in a number of ways. The writer observed that certain nutrient substances different in their chemical constitution may induce development of certain characters and inhibition of others, such as sporodochia, sclerotia and pigment. In addition, the ratio between dextrose and peptone, in certain culture media, was observed to be a factor influencing sporulation (sporodochial macroconidia) versus aerial growth and vice versa. In culture media rich in dextrose sporulation was found to be abundant while development of aerial mycelium was very poor. The reverse took place, however, in culture media rich in peptone and poor or lacking entirely in dextrose. Amygdalin was

observed to induce the development of spores of approximately uniform size and septation. Colorless sclerotia and similar plectenchymatic bodies are not constant characters in the development of certain species. Such characters may appear in the culture of the initial isolation and in a few transfers but seldom reappear in later cultures. Bluish sclerotia, however, constitute a constant morphological character not affected by prolonged cultural conditions, in certain species.

DISCUSSION

The mere fact that soil is the natural habitat of Fusaria might be the chief reason for explaining the occurrence of such a great number of species of these organisms on onion roots. What is understood by specificity, in the case of certain Fusarium diseases, does not seem to apply in this particular disease. Species which have been reported by previous investigators as being pathogenic on plants such as potato, pepper, pea and tomato have also been found to occur on diseased onion roots, and in the case of *F. rhizochromatistes*, to produce pink root symptoms on two or three different plants.

These observations lead to the conclusion that the study of diseases induced by Fusaria present a very complicated aspect, due, on the one hand, to the specificity of certain of these organisms in regard to their host, and, on the other hand, to the non-specificity of certain others.

The writer suggests that, in a systematic study on Fusaria, only those nutritive substances whose chemical composition is known should be employed for the development of certain morphological characters. The results which were obtained in both solid and liquid media with dextrose and amygdalin were very satisfactory. Great confidence should not be placed on media prepared with vegetable tissues because of the variation of these tissues in their chemical composition, especially, when obtained from different sources and at different seasons.

SUMMARY

Twenty different species and varieties of Fusarium, some new and others already described and named, have been isolated from diseased and dead onion roots with and without symptoms of pink root disease. Some of these organisms are known to produce wilt and rot diseases on potatoes, tomatoes, peppers and certain other plants.

The new species which are reported and described in this paper are the following:

Fusarium cromyophthoron n. sp.,
Fusarium rhizochromatistes n. sp.,

Fusarium rhizochromatistes var. **microsclerotium** n. v.,
Fusarium sclerostromaton n. sp.,
Fusarium loncheceras n. sp.
Fusarium loncheceras var. **microsporon** n. v.

The development of certain morphological characters has been observed to be influenced by the chemical nature of the substratum. Protein substances induce the development of aerial mycelium growth while at the same time decrease the rate of production of sporodochial macroconidia. The reverse, however, takes place when dextrose is used as the source of carbon in the medium.

LITERATURE CITED

(1) APPEL, OTTO and H. W. WOLLENWEBER. Grundlagen einer monographie der gattung Fusarium (Link). Arb. Biol. Anst. f. Land. u. Forstw. Bd. 8. *207 p., 10 figs., 31 pl. (1 col.).* 1910.

(2) CARPENTER, C. W. Some potato tuber-rots caused by species of Fusarium. Jour. Agric. Res. 5: 183–210. *Pl. 14–19 and 2 col. pl.* 1915. Literature cited, p. 208–209.

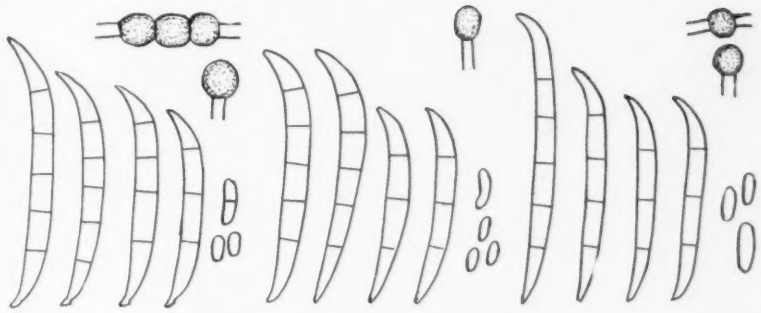
(3) SHERBAKOFF, C. D. Fusaria of potatoes. Cornell Univ. Agric. Exp. Sta. Memoir 6: 87–270. *7 col. pl.* 1915. Literature, p. 269–270.

(4) ————————. Fusaria of wheat and corn. Phytopath. 12: 45. 1922.

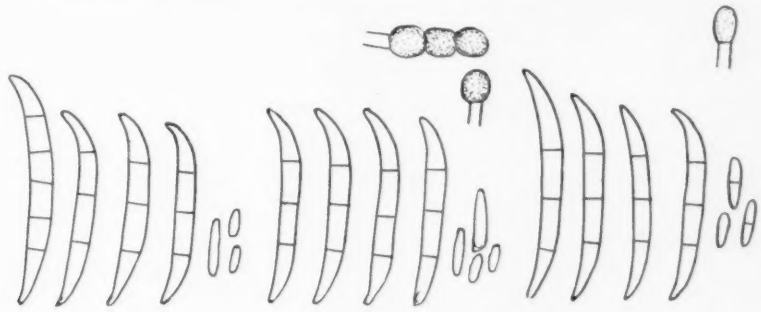
(5) TAUBENHAUS, J. J. and MALLY, F. W. Pink root disease of onions and its control in Texas. Texas Agric. Exp. Sta. Bul. 273. *43* p. 1921.

(6) WOLLENWEBER, H. W. Indentification of species of Fusarium occurring on the sweet potato, *Ipomoea batatas*. Jour. Agric. Res. 2: 251–286. *Pl. 12–16.* 1914. Literature cited, p. 284–285.

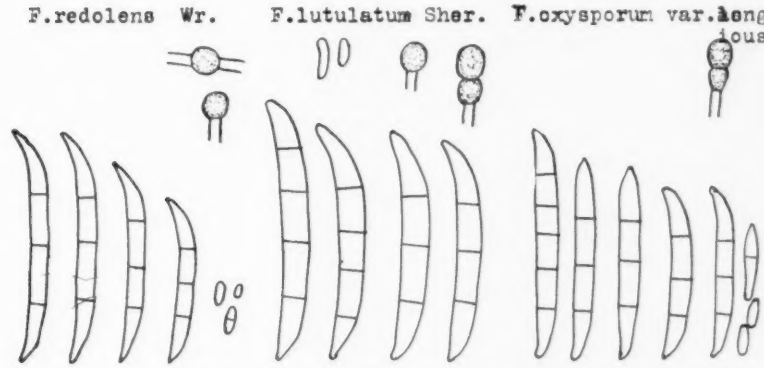
(7) ————————. Studies on the Fusarium problem. Phytopath. 3: 24–50. *Pl. 5.* 1913.



F.oxysporum Scht. F. malli Taub. F.cromyophthoron, n.sp.



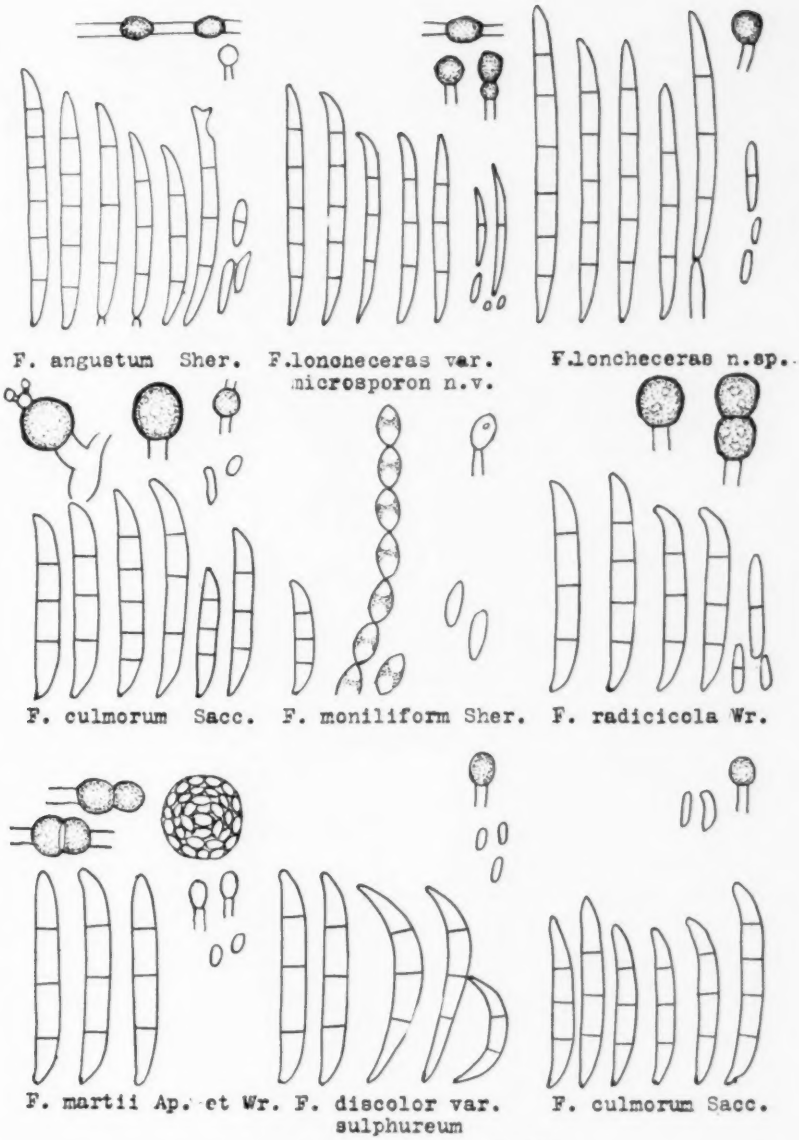
F.redolens Wr. F.lutulatum Sher. F.oxysporum var.longiosus.



F.oxysporum var. resupinatum Sher. F. discolor Ap.et Wr. F. orthoceras var. triseptatum Wr.

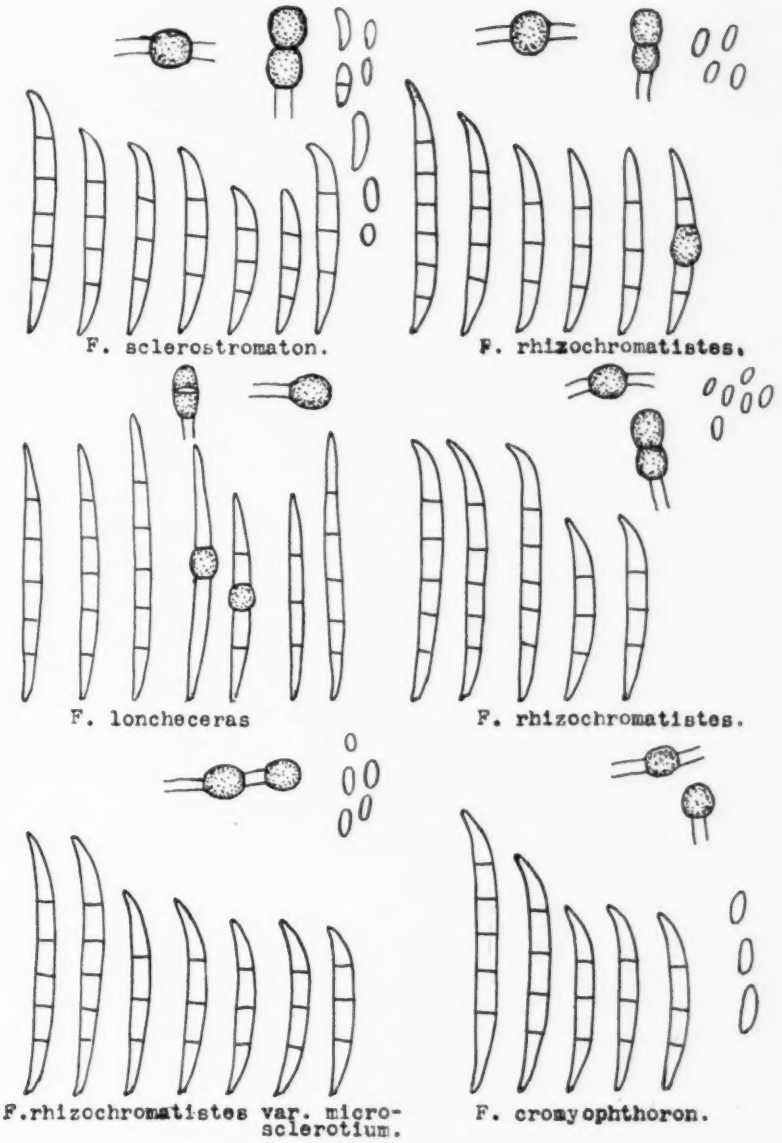
FUSARIA FROM ONION ROOTS

UNIV. OF MICH.



FUSARIA FROM ONION ROOTS

UNIV. OF MICH.



FUSARIA FROM ONION ROOTS

UNIV. OF MICH.

BIOLOGICAL AND CULTURAL STUDIES OF EXOASCUS DEFORMANS

A. J. Mix

With Two Figures in the Text

The fact that the peach leaf curl fungus, *Exoascus deformans* (Berk.) Fuckel, can be grown in its so-called conidial form in laboratory culture media seems to have been realized by several investigators, but no extended study of its behavior in culture has been made.

Brefeld (1) found that spores of this fungus, and also those of *Taphrina rhizophora* Johans. (*Taphrina johansonii* Sadebeck) would bud readily in nutrient solutions, and that the oval "conidia" thus formed would continue indefinitely to generate new conidia by budding after the manner of yeast cells. A thick precipitate formed in the cultures of *Exoascus deformans*, consisting entirely of oval conidia, and though both fungi were kept alive in nutrient solutions several months, no case of germination by germ-tube or of mycelium formation was observed. The conidia of both forms were found viable after cultures had remained dried out for some months. Brefeld makes no mention of special media used with these fungi, and one can only infer from his description (2) of methods used in culturing fungi, that he may have employed a variety of liquid media.

Sadebeck (8) obtained results similar to those of Brefeld with cultures of the same two forms, and also succeeded in keeping conidia of *Exoascus tosquinetii* (Westend.) Sadebeck in culture for a short time.

Pierce (6) grew *Exoascus deformans* in various nutrient solutions, such as extract of malt, sterilized beer, solutions of various sugars, etc., and found the cells to bud readily like yeasts, but could not, in spite of many efforts with special media and with varying environmental conditions, bring them to filamentous germination. Short promycelia from ascospores were observed in some cultures, but Pierce believed that such germination had occurred under natural conditions on the peach leaf, and that the germinated spores were transferred from the leaf in preparing the cultures.

More recently Klebahn (5) reports obtaining pure cultures of the following forms: *Taphrina tosquinetii* (Westend.) Magnus [*Exoascus tosquinetii* (Westend.) Sadebeck], *T. epiphylla* Sad. [*Exoascus epiphyllus* Sadebeck], *T. sadebeckii* Johans., *T. aurea* (Pers.) Fries, and *Taphrina* sp. from *Betula pubescens*. When grown on "Salepagar" these fungi formed "bud-conidia" but no mycelium. Spores from cultures of *T. tosquinetii* were used in successful inoculation experiments on *Alnus glutinosa*, young leaves only proving susceptible.

ISOLATION OF THE FUNGUS

The studies to be reported in the present paper were begun in May, 1920, with the isolation of *Exoascus deformans* from the surface of peach leaves. Mature asci and spores were scraped from leaves into drops of water and dilution plates were poured with potato dextrose gelatin. Single asci were marked under the low power of the microscope. Groups of budding conidia developed within the asci and spread out from their tips into the medium within twenty-four hours. At the end of three days the colonies thus formed were visible to the unaided eye. Transfers of colonies sufficiently far apart to be free from contamination were made to tubes of potato dextrose agar. Six single-ascus strains were thus secured.

The fungus grew slowly, forming colonies superficially resembling those of a yeast, and attaining a size of approximately 5×15 mm. at the end of eight weeks. Mounts from these colonies showed many conidia in all stages of budding, and several spores with short, thick germ-tubes or short (three- to five-celled) mycelia.

The cultures were kept at room temperature, and during a six-weeks absence in early summer, were stored in a laboratory cupboard. Subsequent transfers to similar media made very feeble growth, and after several attempts with different media the cultures were discarded.

In May, 1921, the fungus was again isolated. Dilution plates were poured with cleared and filtered potato dextrose agar. Two single-ascus cultures were thus secured, and one culture from a colony forming around a group of several asci lying together in the agar. Additional cultures were secured by transfer from colonies not known to result from ascospores, but which appeared identical under the microscope with the single-ascus colonies. Isolations were also made by streaking the surface of poured agar plates with a suspension of asci and spores in sterilized water. Colonies which resembled superficially those of *Exoascus deformans* were transferred to tubes of potato dextrose agar.

Some of the cultures thus secured were placed in the refrigerator; others were left at room temperature, and when subcultures were made on June 27, many of the transfers from the room-temperature lot failed to grow. Following this experience all stock cultures were kept in the refrigerator.

In all, fourteen strains were obtained from the isolations of 1921, of which two were known to be single-ascus strains. Most of the work reported below was performed with these single-ascus strains, except that in 1922 one or more of the fresh cultures of that year were included in all tests, for comparison.

BEHAVIOR OF EXOASCUS DEFORMANS IN CULTURE

The budding conidia of *Exoascus deformans* have been successfully cultivated on several kinds of laboratory media, as: potato dextrose agar,

potato sucrose agar, potato maltose agar, peach-leaf agar with and without dextrose, similar agars prepared from a decoction of curled leaves, potato dextrose gelatin, potato dextrose broth, sweet potato, carrot, and beet plugs, steamed corn meal, and steamed rice. On the following media restricted growth or none at all was obtained: dextrose agar, sucrose agar, maltose agar, water agar, beef-broth agar, beef-broth gelatin, beef broth, corn-meal agar, oat agar, starch agar, soil-dextrose agar, potato plugs, and bean pods. Most vigorous growth was obtained with sweet potato, carrot, and beet plugs, potato dextrose broth and potato dextrose agar. The two last-named media were used for most of the culture work.

In potato dextrose agar plates, kept in the refrigerator, colonies are visible on the third day. Growth is slow, colonies attaining a diameter of about three millimeters in twelve days. Surface colonies are few, round,[1] sharply circumscribed, compact, with entire edge; convex to pulvinate, or umbonate with a large nipple; moist, shining, opaque; in color white, tending towards pink. Buried colonies are lens-shaped. Deep colonies are flat, spreading, opaque or translucent, with a denser center. Examination of a colony with the low power of the microscope reveals a compact mass of round to oval cells.

Colonies in potato dextrose gelatin plates are similar but smaller, surface colonies are more numerous, and no buried lens-shaped colonies are found.

On potato dextrose agar slants growth is uniform along the line of inoculation; the colony superficially resembles one of bacteria or yeasts; is convex, smooth, glistening, moist, in color white; at the end of ten days becoming dry, and color changing from white towards pink. Older cultures become a delicate pink color, which it has not been possible to match by means of Ridgway's color chart, though a three-months culture has been found to approximate 9″ f, pale vinaceous pink.

In potato dextrose broth growth is confined to the formation of sediment, the surface and body of the liquid remaining clear. The sediment is white, and flocculent when disturbed. In old broth cultures a white film forms on the side of the tube, near and above the surface of the liquid.

In potato dextrose gelatin stab-cultures growth occurs on the surface of the gelatin, following down the line of puncture only gradually as the latter dries out. No liquefaction occurs, even though cultures are preserved until quite dessicated.

Growth on other solid media is uniform in appearance with that on potato dextrose agar, except for variations in rate and amount of growth,

[1] This description, employing terms used in describing colonies of bacteria, is given for the reason that bacteria and yeast-like fungi may occur in plates when *E. deformans* is being isolated.

and a tendency toward modification of the color of the colony by the color of the medium. The latter phenomenon is especially marked in cultures on vegetable plugs.

MORPHOLOGY OF EXOASCUS DEFORMANS IN CULTURE

In young cultures in various media, and in active parts of old cultures, as for example, the buried portion of a colony next to the surface of the agar, the cells are of a type that may be designated budding conidia. They are somewhat variable in shape but chiefly round to oval, even more variable in size (2.4 × 3.6 to 6.3 × 8.6 microns), thin-walled, with fine or coarse granular contents, and sometimes with vacuoles. Budding occurs, as in

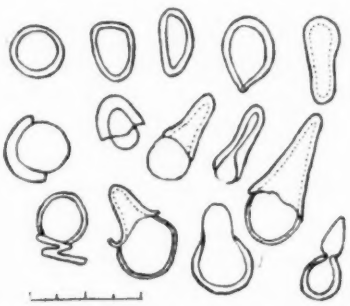


Fig. 1. Resting spores of *Exoascus deformans* from culture. Several stages of germination are shown. Each division of the scale represents a distance of five microns.

yeast cells, by the outgrowth of a daughter cell which resembles the parent, and which later enlarges and becomes free. There is no tendency toward colony formation by the coherence of cells in successive stages of budding, as in yeasts, but chains of cells forming short mycelia may occur, as noted later.

In old cultures, and especially in central and surface portions of the colony, removed from the substratum, budding is less evident. The cells are for the most part larger, often with highly refractive contents, and may possess thin or thick walls. The thick-walled cells are so peculiar in appearance and behavior that they have been tentatively designated resting spores. Such resting spores are comparatively large (5.1 × 5.9 to 11.1 × 15.8 microns), are spherical, oblong, or almost conical (figure 1) in shape, and possess a thick, highly refractive wall, and coarse, refractive, oily contents. They germinate (figure 1) by rupture of the thick outer wall and emergence of a thin-walled cell, which may continue the process of budding.

Pierce (6) describes and figures the formation of asci from ascogenous cells, and states that the emergence of the protoplast from the ascogenous cell resembles the germination of a thick-walled spore. He also suggests

that the ascogenous cells may be capable of enduring a considerable rest period. He searched for such resting ascogenous cells on swollen peach twigs without success. In view of the above it seems possible that the resting spores developed in culture may indicate an approach to the asciferous stage. If so, they also mark the limit of growth in artificial culture, as nothing resembling even an immature ascus has been observed.

Whatever they may be morphologically, it seems worth while to point out that if the fungus has a saprophytic period of development in nature, such resting spores are undoubtedly formed, and may perhaps aid in tiding

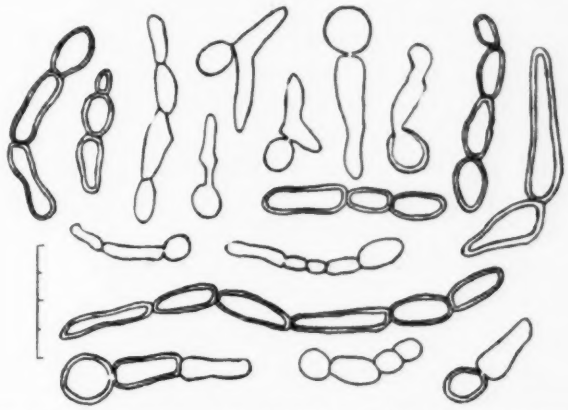


Fig. 2. Various types of germ-tubes and of short mycelial threads formed by *Exoascus deformans* in culture. Each division of the scale represents a distance of five microns.

over unfavorable conditions. Whether they are actually more resistant than the thin-walled conidia is a matter of conjecture, though, as mentioned below, old cultures containing such thick-walled cells seem to be less readily devitalized by high temperatures than young cultures. The thermal death-point of cells from old and young cultures was, on the other hand, found to be the same.

Exoascus deformans has never formed a well developed mycelium in any cultures. Germination by germ-tube, in lieu of budding, has been found to occur occasionally in all of the culture media employed, and this has usually been accompanied by a tendency toward mycelium formation. Three-, four- and five-celled threads are not uncommon, and often longer threads have been observed. Such threads are irregular in diameter and resemble the mycelium found in diseased tissues. Sometimes, however, the thread is a mere chain of oval cells, such as might be formed by successive budding of conidia. The peculiar plate septa described by Pierce and others have not been observed. Types of mycelium formed in culture are shown in figure 2.

In spite of considerable study directed to that end, it has not been possible to correlate the tendency to form germ-tubes and mycelium with any particular kind of culture medium, with any condition of environment to which the cultures have been subjected, or with age of a particular culture. Certain media, notably carrot plugs, seem to be especially favorable to growth by budding, but germ-tubes and short mycelia have been observed in old carrot cultures.

TEMPERATURE RELATIONS IN CULTURE

Mention has been made of the devitalization of cultures kept in the laboratory at temperatures prevailing in early summer. This indicated a rather low maximum temperature for growth. Apparatus was not at hand to determine the temperature range as closely as might be desired. The data obtained with available incubators are presented in table 1. It was necessary to employ test-tube cultures, four tubes of each strain of the organism being placed at each different temperature. Actual measurement of colonies not being convenient, a method of estimation was adopted. The growth of strain "e" at the most favorable temperature was assigned an arbitrary value of ten, and other values were obtained by careful comparison with this as a standard. The humidity factor was not studied, but the air surrounding the cultures was kept at saturation point in every case.

TABLE 1—*Effect of temperature on growth of Exoascus deformans on potato dextrose agar*

First test. Growth estimated at the end of eleven days.							
Culture.	Growth values at:						
	3° to 8° C.	9° to 13° C.	23° to 25° C.	30° C.	35° C.	40° C.	45° C.
e	7	7	10	0	0	0	0
f	5	7	8	0	0	0	0
g	6	6	8	0	0	0	0
Average:	6	6.6	8.6	0	0	0	0

Second test. Growth estimated at the end of fifteen days.				
Culture.	Growth values at:			
	6° to 10° C.	19° to 25° C.	26° C.	30° C.
e	7	10	[1]	0
f	9	10	5	0
g	9	11	7	0
Average:	8.3	10.3	6	0

[1] Lost by contamination.

The minimum temperature for growth was not learned, but it is evident that it is well below 10° C. The optimum apparently lies in the neighborhood of 20° C. (if not lower), and the maximum somewhere between 26° and 30° C.

The thermal death-point of the organism in tubes of potato dextrose broth was determined. Freshly inoculated tubes were subjected to the desired temperatures, placed in the refrigerator and left for some days, until growth was abundant in a set of control tubes inoculated at the same time. Observations were then made and a loopful from each tube transferred to an agar tube for confirmation. Final data from observation of growth in agar tubes agreed in all cases. The organism was found to survive ten minutes immersion in the water bath at 45° C., and to be killed by ten minutes at 46° C., and at higher temperatures. No difference was apparent between old cultures containing resting spores and young cultures.

It was thought interesting to determine the length of time necessary to devitalize a culture by exposure to a temperature too high for growth. Broth and agar cultures, previously kept in the refrigerator, were placed in an incubator at 30° C., and daily transfers were made to tubes of potato dextrose agar until such transfers showed that the original cultures were dead. Three such tests were made, employing eight different strains of the organism, and in one test a comparison was made of old cultures showing resting spores with six-day-old transfers of the same strains. Attenuation and even death of the organism occurred as early as the fourth day of exposure at 30° C., while the longest period that any strain survived was eight days. In the case of the six-day-old cultures all strains of the organism were dead at the end of four days, while some of the old cultures of the same strain survived as long as six days. Exposure of cultures to 30° C. for short periods alternated with equal periods in the refrigerator resulted in the death of the organism in twelve days, in the case of old cultures, and in seven days when young cultures were employed.

The inability of the organism to grow at high temperatures may explain the fate of curled leaves on the arrival of hot weather. Leaves bearing asci have been observed to die quickly if a few days of hot weather occur. Such curled leaves are invaded by several saprophytic fungi (whose identity is unknown) while still attached to the tree, resulting in the death of the leaf or its fall. Isolations of ascospores from such leaves are very difficult because of these contaminating organisms.

SURVIVAL OF SPORES IN DRIED FILMS

It is evident from spraying experiments conducted by Pierce and others that some spore-form of *Exoascus deformans* is present on the surface of peach buds and twigs prior to the time that the buds swell in the spring. The success of fall spraying reported by Reddick and Toan (7) indicates that spores may be present on twig surfaces in the fall. It is the general belief, following the evidence of such spraying experiments, that ascospores or their descendants pass the entire summer and winter on the surface of healthy peach twigs and buds.

If this belief is true such a spore-form must possess high resistance to dessication, and it must be capable of enduring higher temperatures than have been found fatal to the fungus when in active condition. As mentioned earlier, a few days' exposure to a temperature of 30° C. (86° F.) is sufficient to kill the fungus in culture. Stevens (9) has called attention to the fact that twigs of trees may have at times temperatures considerably above that of the air, and summer air temperatures, in Kansas at least, are frequently above eighty six degrees.

Rather than to postulate the existence of an undiscovered spore-form, it seems reasonable to look for this resistance in the dessicated conidia or resting spores such as are formed in culture. That such cells can withstand drying is indicated by the following results. Cells from culture were placed in drops of sterilized water on sterilized cover slips within sterilized petri dishes. The drops were allowed to dry out at room temperature; this occurred within twenty-four hours. At intervals of one day, or longer, cover slips were dropped into tubes of potato dextrose broth and these tubes kept in the refrigerator until growth was evident. Confirmation of survival was made by means of transfers from these broth tubes to tubes of potato dextrose agar. The first test, in which the dried films were kept both at room temperature and in the refrigerator, was concluded at the end of sixty days, the organism being still viable. In a second test three sets of cover slips were prepared; one set was kept at room temperature, another in the refrigerator, and the third at 30° C. Some cells were found to survive for 140 days at 30° C., and for 315 days at the lower temperatures.

The thermal death-point of the cells in these dried films was determined. Glass slips on which the organism had been subjected to dessication for ten days were placed in sterilized test tubes of 8 mm. internal diameter, and subjected to various temperatures in the water bath. They were then dropped into tubes of potato dextrose broth. Transfers were later made from these broth tubes to agar tubes for confirmation. The dessicated cells were found to survive ten minutes' exposure to 95° C. and to be killed by ten minutes at 100° C.

These results indicate a degree of resistance possessed by the conidia of *Exoascus deformans* which is perhaps sufficient to account for the survival of the organism from one year to the next.

INABILITY TO CAUSE ALCOHOLIC FERMENTATION

The question has been raised whether the conidia of *Exoascus deformans* can cause alcoholic fermentation. According to Pierce (6) Sadebeck[2] states that the conidia of some other species of Exoascaceae possess this power.

[2] Pierce gives no citation, and the writer, having examined only two of Sadebeck's numerous articles on the Exoascaceae, is unable to confirm this statement.

Just why Exoascus conidia should be suspected of this faculty is not apparent, except that they resemble yeast cells in their manner of budding, a habit that is shared by a large number of other fungi which are incapable of fermenting the common sugars. Tests on this point, which consisted in growing the fungus in ten per cent solutions of dextrose, sucrose, and maltose, with the addition of a little potato broth, were entirely negative.

ACID-ALKALI RANGE IN CULTURE

Some study was made of the toleration of *Exoascus deformans* for varying degrees of acidity and alkalinity in culture media. The media employed were potato dextrose agar and potato dextrose broth. Varying amounts of 5 per cent and 50 per cent lactic acid and of N/10 and N/1 NaOH were added to a constant volume of culture medium, as suggested by Hopkins (4). The pH was determined by the colorimetric method proposed by Gillespie (3). In table 2 are presented the results of a test employing poured plates of potato dextrose agar. Six plantings, each from a separate strain of the fungus, were made in each plate and the series was run in duplicate, so that measurements reported are the average of twelve colonies. Measurements were not made closer than the whole part of a millimeter; the fractional values given result from averaging whole numbers together.

TABLE 2—*Growth of Exoascus deformans on potato dextrose agar of different pH*

pH	Diameter of colony in mm. at the end of ten days	Diameter of colony in mm. at the end of twenty days	pH	Diameter of colony in mm. at the end of ten days	Diameter of colony in mm. at the end of twenty days
?(30)[1]	3.5	5.9	6.2	4.3	6.4
?(20)[1]	2.5	4.3	6.8	4.4	6.7
3.3	3.6	5.7	7.2	4.4	6.4
3.5	3.8	6.1	7.7	4.5	7.0
3.8	4.0	6.0	8.2	4.6	7.0
4.3	4.3	6.8	8.5	3.7	5.9
4.6	4.2	6.7	8.6	4.0	6.2
4.9	4.3	7.7	9.2	3.7	6.0
5.4	4.5	7.0	9.6	3.3	6.0
5.8	4.2	6.7	?(15)[2]	2.5	4.1
6.0	4.5	6.3	?(20)[2]	2.1	4.0

[1] pH unknown. The figure in parenthesis indicates the number of drops of 50 per cent. lactic acid added to 50 cc. of medium.

[2] pH unknown. The figure in parenthesis indicates the number of drops of N/1 NaOH added to 50 cc. of medium.

From the data presented in table 2 it is evident that this fungus has a wide range of tolerance of acid and alkali when grown on potato dextrose agar, the limits of growth being beyond the range of the indicators employed (pH 3.3 to pH 9.75). No very significant growth differences appear but

the optimum concentration for growth seems to be in the neighborhood of pH 5. In three preliminary trials, not including so wide a range of hydrogen-ion concentrations, and therefore not reported in detail, the maximum growth occurred between pH 4 and pH 5.

A series of flasks of potato dextrose broth was treated so that the pH varied from 3.3 to 9.4, with an interval between adjacent flasks of approximately five tenths of a pH unit. These flasks were inoculated with a strain of *Exoascus deformans* and kept in the refrigerator for twenty days. The fungus grew well in all flasks. There was no apparent difference in amount of growth in different flasks and no attempt was made to measure it. Growth was inhibited in flasks containing twenty drops of 50 per cent lactic acid in 50 c.c. of broth, and in those containing ten drops of N/1 NaOH in the same amount. The pH in each case was beyond the range of indicators used and was not determined.

In the test just described only the initial pH of the solution was considered. A separate study was made of the effect of the fungus on the pH of the medium. The results of this are reported in table 3.

TABLE 3—*Effect of the growth of Exoascus deformans upon the pH of potato dextrose broth*

Series A		Series C	
Initial PH	pH at the end of five days	Initial PH	pH at the end of twenty days
3.9	3.9	3.9	3.8
5.7	4.5	5.8	4.5
6.8	6.8	6.8	6.4
7.2	7.4	7.2	6.6
8.3	7.2	8.0	6.6
8.6	7.4	8.7	6.8
Series B		Series D	
Initial PH	pH at the end of fifteen days	Initial PH	pH at the end twenty-five days
3.9	3.8	3.9	3.8
5.5	4.7	5.1	4.6
6.8	6.3	6.8	6.2
7.2	6.6	7.2	lost
8.1	6.9	8.2	6.6
8.6	6.8	8.7	6.8

It will be noticed that in all flasks, except those with an initial pH of 3.9, a rather pronounced shift occurred in the direction of increased acidity. Whether there is any greater significance in these results cannot be stated without further investigation.

ATTEMPTED ISOLATIONS FROM THE SURFACE OF PEACH TWIGS

It was hoped to obtain some confirmatory evidence of the presence of spores of *Exoascus deformans* on the surface of peach buds and twigs by means of isolations from such surfaces. This was attempted in spite of the fact that the isolation of this fungus is extremely difficult when other, faster growing forms are present. The method was to pour dilution plates or to streak the surfaces of poured plates with sterilized-water washings of buds and twig-fragments. A large number of buds or twig-pieces from various parts of trees which had been severely affected with curl were taken for each attempt. Several variations of the general method were tried, such as varying the time of soaking the buds, centrifuging the washings, etc., but these are not worth describing. Attempts were made once a month or oftener during two seasons, beginning in August and ending after leaves were well expanded the following spring. Thirty-five separate trials were made and a variety of organisms secured, but in no case *Exoascus deformans*.

The organisms obtained deserve brief mention as indicating the nature of the surface flora of peach twigs. By far the commonest organism appearing was *Dematium pullulans* De Bary and Low. Very young colonies of this fungus are deceptively like those of *Exoascus deformans*, but they are readily distinguishable as soon as mycelium formation begins. *Dematium pullulans* seems to be always present on peach twigs and buds. Bud scales placed in slide-drop cultures of water or nutrient solutions have invariably developed mycelium and spores of this fungus within twenty-four hours, growth being so abundant as to obscure any other organisms that may have been present.

No attention was paid in these isolations to filamentous fungi, but twelve yeast-like forms were secured, all apparently different. These forms have round to oval cells, reproducing by budding, and difficult to distinguish under the microscope from budding conidia of *Exoascus deformans*. Most of them can readily be told by color or by surface character of the colony, but a few of them approximate so nearly the colony characters of *Exoascus deformans* that cultures must be saved for some time to render identification certain. These organisms apparently belong to the genus *Torula* Turpin,[3] but as they have no known importance no attempt has been made to identify them.

ATTEMPTED ISOLATIONS FROM THE SOIL

A possibility that has received scant attention is that *Exoascus deformans* may overwinter in the soil and that soil particles and spores may be blown to the twigs in late winter or spring. Following the high winds which

[3] In this genus Hansen places a number of yeast-like organisms which are not known to form ascospores. It is distinct from the genus *Torula* of Persoon.

frequently occur during a Kansas winter, peach twigs may be so coated with dust that they are gritty to touch, and water used in preparing bud washings may be perceptibly discolored. The possibility does not seem so clear in localities where the ground is covered with snow throughout the winter, nor in orchards where the soil is not cultivated.

Failure to secure the organism from twigs where *a priori* one would expect to find it, made it seem somewhat hopeless to attempt the isolation of *Exoascus deformans* from the soil. Some attempts were made, however, but none were successful. The plates yielded, besides bacteria, two of the common "budders" isolated from twigs, but not *Exoascus deformans*.

Some indirect evidence as to the viability of the fungus in the soil was obtained. A fair amount of growth occurs in plates of soil dextrose agar, and in tubes of soil with potato dextrose broth added. In soil agar and in tubes of sterilized soil no noticeable growth occurs, but the fungus remains alive and capable of subsequent growth on favorable media, when such soil cultures are kept in the refrigerator for several months. The organism has been recovered from such soil tubes after they have become quite dried out.

ISOLATIONS FROM THE INTERIOR OF DISEASED LEAVES AND STEMS

Isolations of the fungus from the interior of diseased leaves and stems were attempted as follows. Curled leaves and stems of various ages, up to nearly the time of formation of asci, were immersed in alcohol, then in $HgCl_2$ 1 : 1000 for two minutes, rinsed five times in sterilized water, transferred to sterilized petri dishes, and chopped into fragments. These fragments were transferred by means of sterilized instruments to tubes of potato dextrose agar. A few attempts were made in 1921, and a colony of *Exoascus deformans* developed from a leaf fragment in one tube, out of a total of nearly one hundred and fifty tubes. Most of these tubes were kept at room temperature, the low temperature requirements of the fungus not being fully realized.

In 1922 three attempts were made, on April 18 and 24, and May 10, forty tubes being used on each date. Two cultures of *Exoascus deformans* were obtained from the first set of tubes, two from the second, and five from the third.[4]

In these isolations, the colonies appeared in a week or two after planting, and holding the tubes until July 12, together with addition of sterilized water on June 7, to compensate for drying out of the agar, did not serve to induce development of any more colonies. Many of the leaf and stem frag-

[4] It had been planned to apply this method of isolation to a question that has never been satisfactorily settled: how long *Exoascus deformans* may survive in twigs that have not been killed by the disease. The number of successful isolations, nine out of a possible hundred and twenty, was too low to encourage any attempt in this direction.

ments retained their original form and color for weeks, some until the tubes were finally discarded. At this time microscopic examination was made of several leaf fragments, revealing internal mycelium which to all appearances was normal.

INOCULATIONS

Successful inoculations were performed in the spring of 1922 on old peach trees of unknown variety. On March 20, when the buds on these trees were considerably swollen but not yet pushed out, several twigs were sprayed with a solution of formalin, one part to two hundred parts of water. The evidence that such spraying would protect the buds from natural infection was that several twigs sprayed in the same manner in the spring of 1921 remained free from curl, while other twigs on the same trees were badly infested.

Clear, mild weather followed and the buds pushed slightly, some showing one eighth inch of green tip on March 24, when the first inoculations were made. A considerable amount of inoculum from potato dextrose agar and carrot plug cultures of a single-ascus strain was smeared over the tips of the buds and worked down in between the emerging leaf tips. Every leaf bud on a chosen twig was inoculated. A few twigs were left uninoculated, as controls.

These inoculations were made at the beginning of a rain period, which, however, only endured a few hours. The same buds were again inoculated, using similar cultures, at the beginning of subsequent rain periods. These later inoculations were as follows: on March 25, rain ensuing for several hours; on March 29, rain or mist prevailing during the day and following night; on April 3, followed by a rain period of several days' duration. Cold weather between March 24 and April 3 had delayed the development of buds so that on the latter date they were in almost the same condition as when the first inoculations were made. At the end of the rain period which began on April 3 the buds were well pushed, the green tips protruding beyond the bud scales. A few of these young leaves showed a pale yellow or red coloration and slight distortion, suggesting the first symptoms of peach leaf curl. A similar coloration was evident on some leaves as early as March 26. Apparently deepening of color of young peach leaves is not a reliable indication of curl.

Daily observations were made and the first curl was seen on April 18. It was evident as small, light yellow or red, slightly raised spots near the edge of the leaf. Curl from both natural and artificial infections was observed on this date. Counts of infections from artificial inoculations were delayed until May 13, when the disease was so far advanced that no error of diagnosis could be made. Every leaf cluster showing one or more leaves affected

by curl was counted as a "curled bud." Leaf clusters showing no curled leaves were counted as healthy buds. The results of these counts are given in table 4.

TABLE 4—*Results of artificial inoculation of peach trees with Exoascus deformans from pure culture*

Tree	No.	1[1]	Twig	No.	76	Inoculated	Curled	buds	12	Healthy	buds	28
"	"	2	"	"	81	"	"	"	31	"	"	15
"	"	2	"	"	91	"	"	"	5	"	"	55
"	"	2	"	"	84	"	"	"	2	"	"	8
"	"	2	"	"	6	Control	"	"	0	"	"	52
"	"	3[2]	"	"	82	Inoculated	"	"	4	"	"	36
"	"	4[3]	"	"	61	"	"	"	0	"	"	12
"	"	5[4]	"	"	88a	"	"	"	21	"	"	5
"	"	5	"	"	88b	Control	"	"	1	"	"	11
"	"	5	"	"	46	Inoculated	"	"	1	"	"	2

[1] No curl was evident on any other leaf on this tree, though the whole tree was infested in 1921.

[2] No curl on this tree except on inoculated twig.

[3] No curl anywhere on this tree.

[4] Very little curl on this tree, more on inoculated twigs than on any others.

The controls, as indicated earlier, were twigs which were sprayed with formalin and left uninoculated. As a further check on the results of inoculation, counts were made of natural infections on three typical twigs of tree No. 2, the only tree which showed any considerable amount of natural curl. The results were as follows: twig A, curled buds 13, healthy 45; twig B, curled buds 9, healthy 23; twig C, curled buds 14, healthy 34. This gives a total of 36 curl to 102 healthy, to be compared with 96 curl to 161 healthy, resulting from artificial inoculation.

These results are of course open to the criticism that artificially inoculated buds were perhaps also exposed to natural inoculation. In spite of this fact, a study of the results, and a consideration of the occurrence of curl following artificial inoculation on trees otherwise free from the disease, leaves no reasonable doubt but that curl was induced artificially. The percentage of infection secured was not high, but it seems to be fully as high as the percentage of natural infection.

The results reported below are more convincing. Four two-year-old Elberta peach trees were obtained from the nursery in early March, 1922, and planted out of doors. These were sprayed as above with 1–200 formalin. On April 3, at the beginning of the rain period previously described, these trees were inoculated in the same manner and from the same cultures as the older trees. Counts made on May 17 gave the results shown in table 5.

TABLE 5—*Results of artificial inoculation of young peach trees with Exoascus deformans from pure culture*

Tree	No.	1	Inoculated	Curled	buds	8	Healthy	buds	72
"	"	3	"	"	"	7	"	"	72
"	"	2	Control	"	"	0	"	"	83
"	"	4	"	"	"	0	"	"	85

These young trees were on the University campus, some distance away from any other peach trees. All curled leaves were removed and destroyed before asci were formed. The trees were again sprayed with 1–200 formalin in early March, 1923, a few days before inoculations were made.

The results of the 1923 inoculations may be briefly summarized. Several twigs on tree No. 1 were inoculated in the usual manner on March 11, during a rain which lasted for several hours. The buds were considerably swollen and the tips of some leaves were visible. Counts made on these twigs on May 15 gave a total of 49 curled buds and 31 healthy.

On March 27 several more twigs on tree No. 1 were inoculated. The weather was fair, and the twigs were sprayed with water to facilitate the insertion of inoculum into the buds. Twigs on tree No. 1 and tree No. 2 were inoculated in a similar manner on April 2. Rain occurred during the night of April 2, and on April 4, 11, and 12, lasting but a few hours on each date. On May 15 counts showed 5 curled buds and 25 healthy on twigs inoculated March 27; 11 curled buds and 78 healthy on twigs inoculated April 2. Since studies reported earlier in this paper have shown that cells of *Exoascus deformans* from culture possess high resistance to dessication, it seems that the low proportion of infection secured may not have been due to the conditions of inoculation but to the short duration of subsequent rain periods (four to eight hours).

On April 20, when the leaves were entirely out of the buds and considerably expanded, rain occurred from eight in the morning until five in the afternoon. At noon on this date all of the leaves on tree No. 4 were sprayed with a suspension of spores of *Exoascus deformans* in sterilized water. A rain period of about the same duration again occurred on April 22, and thereafter the weather was fair until some time subsequent to the appearance of curl on May 1. Counts on May 15 showed 5 curled buds and 86 healthy on tree No. 4.

Several twigs on tree No. 2, and the whole of tree No. 3 were left uninoculated for controls. Counts on May 15 showed no curl and 50 healthy buds on tree No. 2, and 2 curled buds and 83 healthy on tree No. 3. The curled leaves on this tree were on branches which almost touched some of the inoculated twigs on tree No. 2. It is possible that inoculum from these twigs was splashed or otherwise transferred to buds on tree No. 3.

It is worth mentioning that the most severely infested twigs on any of these trees were inoculated from a single-ascus strain of *Exoascus deformans* that had been in culture since May, 1921. The virulence of the organism had not been lost after cultivation on potato dextrose agar for twenty-two months.

It has not been possible to study the conditions necessary to infection. Several attempts have been made to infect young seedlings at stages varying from the beginning of plumule growth up to seedlings two inches tall with several well developed leaves. All such attempts have failed.

SUMMARY

Exoascus deformans can be readily isolated from ascospore-bearing leaves and grown in a variety of common culture media.

The fungus grows slowly, forming on solid media yeast-like colonies of a delicate pink color.

Cells developed in culture are for the most part budding "conidia," though germ-tubes and short mycelia sometimes occur.

Thick-walled cells are also formed. These cells may burst, allowing the escape of a thin-walled protoplast, a behavior similar to that of the ascogenous cells found in the leaf. Such cells have been tentatively designated resting spores, though whether they are more resistant to dessication and to extremes of temperature than the conidia is not known.

The minimum temperature for growth of the organism in culture is below 10° C., the maximum somewhere between 26° and 30° C., and the optimum 20° C. or lower.

The thermal death-point of the fungus in culture is 46° C.

Cultures are completely devitalized when kept for a few days at 30° C.

Cells from culture are highly resistant to dessication, withstanding drying on cover slips for 315 days. Such dessicated conidia are more resistant to high temperatures than cells in culture, proving viable after 140 days' exposure to 30° C. The thermal death-point of conidia in dried films is 100° C. It seems probable that conidia derived from the budding of ascospores may possess sufficient resistance to survive and cause infection the succeeding spring.

The conidia of *Exoascus deformans* do not induce alcoholic fermentation when grown in solutions of several common sugars.

The fungus has a wide toleration of acidity and alkalinity in culture media, growth occurring at hydrogen-ion concentrations below pH 3.3 and above pH 9.75. The optimum concentration for growth is between pH 4 and pH 5.

When grown in potato dextrose broth with pH adjusted to various points

between 5.1 and 8.7, *Exoascus deformans* induced an increased acidity in the medium. No change occurred in broth with an initial pH of 3.9.

Attempts to isolate the fungus from the surface of healthy peach twigs and buds and from the soil beneath infested trees were unsuccessful.

Isolations from the interior of diseased leaves and stems were successful, but the proportion of successful isolations was very low.

Peach trees were successfully inoculated with conidia of *Exoascus deformans* from culture, and typical curl resulted, these inoculations being performed out of doors when weather conditions were favorable to infection.

Exoascus deformans does not suffer loss of virulence by being kept in pure culture for twenty two months.

Attempts to inoculate very young seedlings grown from peach pits were unsuccessful.

DEPARTMENT OF BOTANY,
UNIVERSITY OF KANSAS.

LITERATURE CITED

(1) BREFELD, OSCAR. Die formen der Ascomyceten und ihre Culture in Nährlösungen. Untersuchungen aus dem Gesammtgebiete der Mykologie **9**: 119–149. Munster. 1891.

(2) ———. Culturmethoden zur Untersuchung der Pilze. Untersuchungen aus dem Gesammtgebiete der Mykologie **4**: 1–35. Leipzig. 1881.

(3) GILLESPIE, L. J. Colorimetric determination of hydrogen-ion concentration without buffer mixtures, with especial reference to soils. Soil Science **9**: 115–136. 1920. References, p. 135–136.

(4) HOPKINS, E. F. Note on the hydrogen-ion concentration of potato dextrose agar and a titration curve of this medium with lactic acid. Phytopath. **11**: 491–494. 1 fig. 1921.

(5) KLEBAHN, H. Infektionsversuche mit Taphrina Tosquinetii. Berichte der deutschen Bot. Ges. **41**: 108–113. 1923.

(6) PIERCE, N. B. Peach leaf curl; its nature and treatment. United States Dept. Agric. Div. Veg. Phys. and Path, Bul. **20**: 11–204. *30 pl.* 1900.

(7) REDDICK, DONALD and L. A. TOAN. Fall spraying for peach leaf curl. Cornell Univ. Agric. Exp. Sta. Circ. **31**: 65–73. *Fig. 29–30.* 1915.

(8) SADEBECK, R. Die parasitischen Exoasceen, eine Monographie. Jahrbr. der Hamb. wissensch. Anst. **10**^{2}: 5–110. 1893.

(9) STEVENS, N. E. Environmental temperatures of fungi in nature. Amer. Jour. Bot. **9**: 385–390. 1922.

PHYLLOSTICTA LEAF SPOT, FRUIT BLOTCH AND CANKER OF THE APPLE; ITS ETIOLOGY AND CONTROL

E. F. Guba

With Plates XII and XIII

A manuscript bearing the above title by the author is in progress of publication by the Department of Horticulture of the University of Illinois. Since this publication is meeting with delay and in order to give others the advantages of the investigation, the following summary of the more important results is given here.

Apple blotch is now present in all states south of North Dakota, Minnesota, Wisconsin, Michigan, Lake Erie and New York and east of New Mexico, Colorado and Wyoming excepting Florida. Its present range in the United States apparently has resulted from early distant shipments of infected apple trees from nurseries in the Ozark apple region. The distribution of diseased plants from points west of the Mississippi River has been noted in recent years.

The morphology of the causal organism, *Phyllosticta solitaria* E. & E., presents characters which warrant the placing of the species in the same group with *Phoma uvicola* B. & C., *Phyllosticata pariae* Desm., *Phyllosticta congesta* Heald & Wolf and the imperfect form of *Guignardia vaccinii* Shear, recently named *Phyllostictina vaccinii* Shear (6). In addition to these morphological relationships the similarity in the life histories of these fungi and their behavior in pure culture suggest that the fungus under consideration belongs to the genus Guignardia. *Phyllosticta solitaria* E. & E. agrees perfectly with the characters of Phyllostictina Syd., emend. von Höhnel (5, pp. 93–95), but it can not be placed in this genus since the emended description of Phyllostictina is in disagreement with the type specimen of *Phyllostictina murrayae* Syd. (7), which is the type species of Phyllostictina.[1] It is only fair to state that Dr. C. L. Shear (6), adhering to the view of von Höhnel, has recently regarded *Phyllosticta solitaria* E. & E. as a good Phyllostictina.

The minimum temperature for growth of the organism in culture is between 5° C. and 10° C., the maximum between 30° C. and 35° C. and the

[1] According to Sydow the genus Phyllostictina is characterized by 1-celled, ovate, hyaline spores and a globose pseudo-pycnidium in which the spores are borne endogenously, one in each pseudo-parenchyma cell, and freed by the histolysis of the cell walls. No conidiospores are present. It appears from the study of type material that Sydow's generic description cannot be emended at least not in the sense of von Höhnel. *Phyllostictina murrayae* Syd. and *Phoma uvicola* B. & C. therefore cannot be co-generic.

optimum between 25° C. and 30° C. The organism in culture survives long exposures to temperatures far below 0° C. The optimum temperature for spore germination lies between 25° C. and 30° C.

Growth and the formation of pycnosclerotia in culture occur irrespective of light or darkness. Canker enlargement and the formation of pycnosclerotia may occur in the winter in Illinois during prolonged warm, moist periods; it usually begins, however, early in the spring (Plate XIII, figs. D and G) after having been suspended for the winter (Plate XIII, fig. C). The enlargement of the canker in the spring is accompanied by the formation of true pycnidia. These are also an important source of inoculum. After August only pycnosclerotia are produced on the growing cankers. These produce spores early in the following year although they are not mature until spring. New cankers appear on the new growth in August and at that time bear only pycnosclerotia (Plate XIII, fig. B). Late appearing leaf and fruit lesions, as the result of infections after July and August, bear only pycnosclerotia which either remain sterile or give rise to pycnospores in the following spring. The primary lesions on the fruit and foliage play an important part as sources of inoculum for summer infections. The pycnidia on the fruit which have already functioned during the season "fill up" and become typical pycnosclerotia[2] in the autumn, in which stage they pass the winter.

Natural infections occurred in Illinois during the period of these investigations as early as April and as late as September. Periods of natural infection were carefully determined by bagging experiments (Plate XII, fig. A). Primary infections began in the period between two and three weeks after the blossoms had fallen.

The cankers are probably the exclusive source of primary inoculum. The overwintering pycnosclerotia on the mummied fruit and fallen leaves give rise to pycnospores in the following spring, but the relative importance of these pycnosclerotia as sources of primary inoculum is probably negligible. Many of these overwintering pycnosclerotia become sterile.

The ascigerous stage of the organism has not been discovered although there are reasons to believe that one exists and that it occurs rarely on decaying leaves and mummied fruits in the spring, as one of the final stages of the pycnosclerotium (Plate XII, fig. D) as is the case with *Guignardia vaccinii* Shear, *G. bidwellii* (E.) V. & R. and *G. aesculi* (Pk.) Stewart.

[2] Reddick (The Black Rot Disease of Grapes. Cornell University Agr. Exp. Sta. Bul. 293, 1911) first used the term pycnosclerotium referring to a pycnidium containing a pseudoparenchyma of large cells which gives rise to a perithecium. Since perithecia have never been observed resulting from the differentiation of the pycnosclerotium of *P. solitaria* the word is here used in a slightly different sense from that of Reddick although the form and structure of the fruit is in all respects the same.

There are three distinct types of fruit blotch, these showing differences in the histology of the affected tissues the result of varietal differences of the host rather than distinct strains of the fungus. These have been designated as the fringed, the pitted and the blistered types of apple blotch.

The fungus stimulates the host to excessive hyperplasia and to the formation of absciss layers (Plate XIII, fig. B).

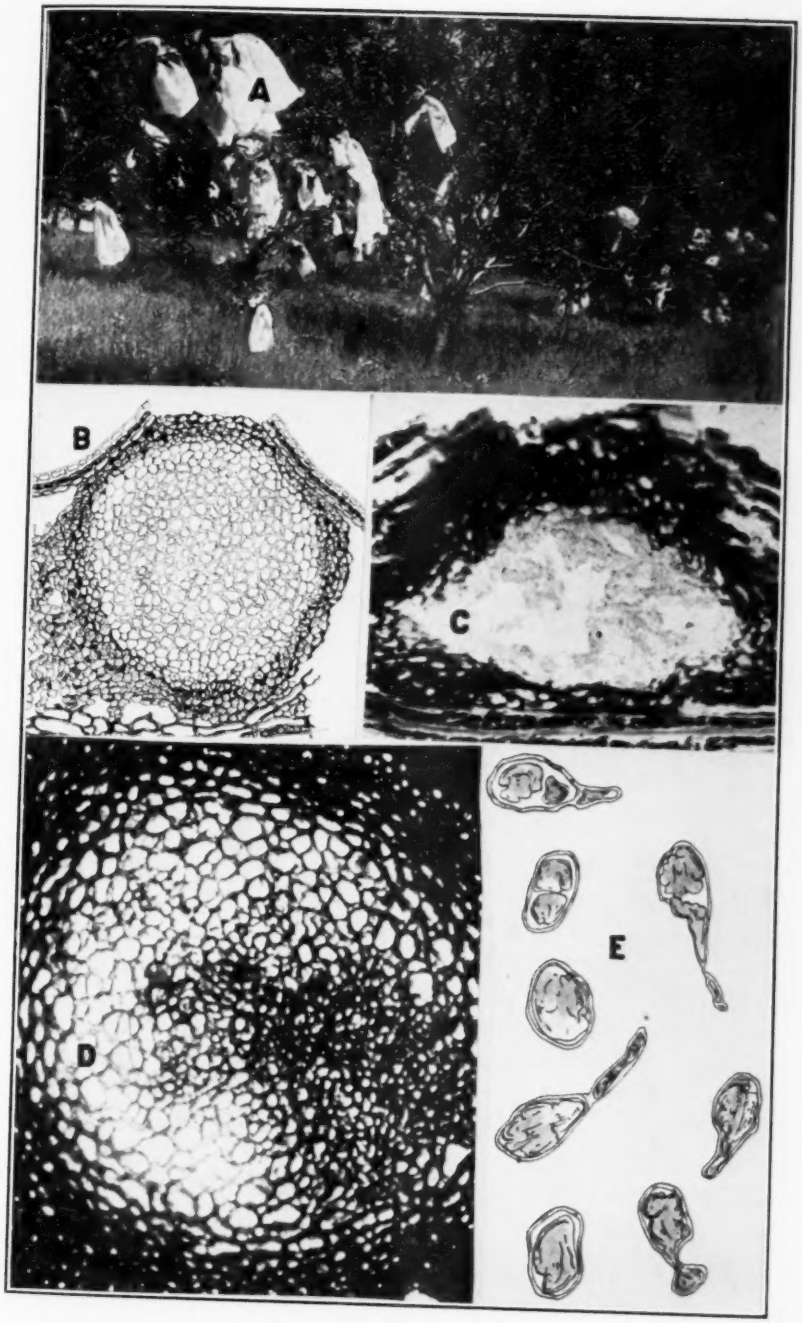
In the bark the cambium is not directly affected. Removal of the fungus by cutting away the canker may therefore be readily accomplished.

The fungus persists in the bark of some varieties indefinitely and in others natural excision occurs within three or four years. Natural excision of the cankers as one means of exterminating or suppressing the fungus as advocated in the early literature is however not dependable.

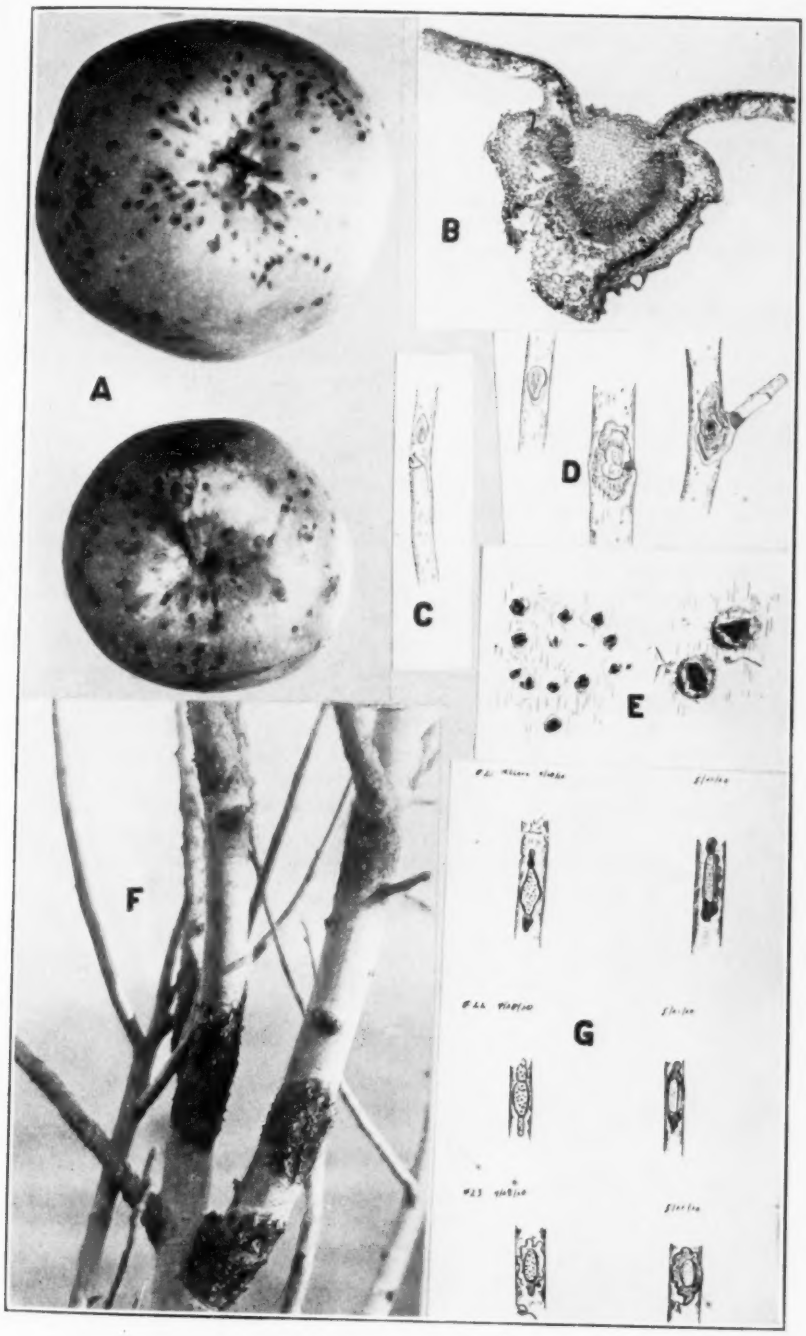
In the opinion of the writer the removal of the cankers on young trees as recommended by Gardner (1, 2) does not appear to be practicable. Other methods of control have accomplished the same end. These methods consist in the selection and planting of disease free trees, delayed dormant and summer spraying, care in the selection of varieties, avoiding near planting of bark-susceptible with bark-resistant varieties and the natural excision of cankers. Plate XIII, fig. F, shows the typical condition of young bark-susceptible varieties of apple trees in Southern Illinois orchards and Plate XIII, fig. A, the result of an ordinary infection of the fruit. Under these conditions especially canker eradication appears neither practicable, profitable or successfully possible.

The fungus may be partially controlled with late dormant sprays of lime sulfur or copper sulfate at concentrated solutions as reported previously by Guba (3, 4). The affected spores are killed and remain in the dead pycnosclerotia (Plate XII, figs. C and E).

Summer sprays of lime sulfur at two and three weeks and bordeaux mixture at four, six and ten weeks after the fall of the blossoms control the fungus perfectly, although with heavy late seasonal rains an additional spray of bordeaux mixture is necessary in August on late susceptible varieties to insure clean fruit. The first blotch spray or what is frequently termed "the 2 week spray" in southern Illinois must be on the trees not later than 2 weeks after 75 per cent of the blossoms have fallen. Lime sulfur and bordeaux mixture are equally effective as indicated by the unpublished results of the author's experiments. For Duchess and Yellow Transparent apples a 2–3–4–6 week spray schedule is recommended and for the Benoni a 2–3–4–6–8 week schedule. These applications supplement the calyx and earlier sprays, the former application also affecting control of the primary infections which in some years may occur prior to the 2 weeks application.



PHYLLOSTICTA ON APPLE



PHYLLOSTICTA ON APPLE

BIBLIOGRAPHY

(1) GARDNER, M. W., et al. Apple blotch. Purdue University Agric. Exp. Sta. Bul. 267. *32 p., 12 fig.* 1923. Literature cited, p. 31–32.

(2) GARDNER, M. W. Origin and control of apple blotch cankers. Journ. Agr. Res. **25**: 403–418. 1923. Literature cited, p. 417–418.

(3) GUBA, E. F. Effect of dormant lime sulphur upon the control of apple blotch. Science, **53**: 484–485. 1921.

(4) ———. The nature and control of apple blotch. Illinois Agriculturist, **26**: 197–198, 218, 222. April, 1922.

(5) HÖHNEL, FRANZ VON. Mykologische Fragmente. Ann. Myc. **18**: 71–97. p. 93–95. 1920.

(6) SHEAR, C. L. Life histories and undescribed genera and species of fungi. Mycologia, **15**: 120–131. *7 fig., pl. 12–13.* 1923.

(7) SYDOW, H. & P., and E. J. BUTLER. *Fungi Indiae orientalis.* (Pars V.) Ann. Myc. **14**: 177–220. *4 figs.* 1916.

EXPLANATION OF PLATES

PLATE XII. Fig. A. Fruit and leaves protected against natural infection in a Duchess orchard. Bagging experiments to determine periods of inoculation. Fig. B. Section through a pycnosclerotium from a canker in December. Fig. C. Section through a pycnosclerotium treated with a late dormant spray of lime sulfur. Fig. D. Section through a pycnosclerotium from a fallen mummied apple in January. Fig. E. Spores from a pycnosclerotium from a canker treated with lime sulfur late in the dormant season.

PLATE XIII. Fig. A. Yellow Transparent apples showing the result of an ordinary infection in Southern Illinois. Fig. B. Section through the midvein of a leaf showing the canker, the abscisss layer and the underlying hyperplasia. Fig. C. A canker during the dormant season. This canker resulted from an infection during the previous growing season. Fig. D. Cankers showing the intermittent areas of growth. Fig. E. Exposed pycnosclerotia in the cankers. Fig. F. A 4-year-old Duchess tree, a typical example of young susceptible apple stock in Southern Illinois. Fig. G. Showing the enlargement of the cankers following the dormant season of the host.

THE PRODUCTION OF SUBSTANCES TOXIC TO PLANTS BY PENICILLIUM EXPANSUM LINK

CLYDE C. BARNUM

WITH TWO FIGURES IN THE TEXT

The toxic action of culture solutions on which *Penicillium expansum* Link had been grown was first observed by the writer in the spring of 1923. At this time, cut stems of vetch (*Vicia gigantea* Hook.) and mint (*Mentha sp.*) were placed with the cut ends of the stems in culture solutions on which the fungus had grown in pure culture, as well as in fresh sterile culture solutions and in equal volumes of tap water. After 24 hours the leaves and stems in the solution on which the fungus had grown were decidedly wilted and in 36 hours the leaves were dry and brittle. The controls in the uninoculated culture solution and in the tap water were fresh and in a growing condition after 48 hours. These results, although not checked up at that time by further work, led the writer to believe that some toxic principle was involved which must have been produced in the culture solution by the fungus. Since no mycelium was present in the solutions used, it was hardly conceivable that the wilting induced by their use was attributable to a choking of the vascular system. This toxicity, induced by a fungus which is commonly known as a strict saprophyte, is similar in many ways to the toxic principle attributed to pathogens, such as Fusaria.

Fahmy (1) points out that *Fusarium solani* (Mart.) Sacc. produced an excretory principle in Richard's culture solution which proved toxic to broad bean plants three weeks old. This principle was found to increase in toxicity with age, and to be thermostable and non-volatile. Fahmy also shows that the injury is not due to the small amounts of ammonium or oxalate ions produced by the organism in pure culture. Haskell (2) reports the presence of a toxic principle in the culture solutions on which *Fusarium oxysporum* Schlect., the cause of potato wilt, had been grown. Injections of these toxic solutions into the stems of healthy potato plants produced definite browning of the vascular tissues and blackening of the leaves.

Later in 1923 further work on the study of the toxic principle produced by *P. expansum* in culture solutions was carried out by the author. Cultures were available at this time on which *P. expansum* had been grown for 9 weeks. Six of these cultures were chosen for the test on growing plant parts. Each culture had grown on 100 c.c. of Czapek's nutrient solution in 250 c.c. Erlenmeyer flasks, a different sugar having been supplied in each case. The six cultures thus represented the growth of *P. expansum* on each of the following carbohydrates: laevulose, lactose, maltose, mannite, pectin

and dextrose. The original concentration of these sugars was 3 per cent in each case. The mycelial felt in each flask was pushed aside sufficiently to allow the insertion of freshly cut ends of terminal leafy stems of *Malva rotundifolia* L. into the culture solution without the cut ends coming in contact with the spores. Controls, consisting of 100 c.c. lots of freshly prepared Czapek's solution containing 3½ per cent dextrose were used and cut stems of the same plants were placed in these with the cut ends immersed in the solution. Tap water controls were also prepared and stems placed in them at the same time. After 18 hours all the branches in the 6 cultures were definitely wilted. (See figure 1.) Wilting was apparent within one hour after the stems were placed in the cultures. After 48 hours the same stems were completely withered and the leaves were dry and brittle. The controls, both in the fresh, sterile solutions and in tap water were fresh and growing at the tips at the conclusion of the experiment.

FIG. 1. Stems of *Malva rotundifolia* in Czapek's solution 20 hours. On left, stems wilted in solutions on which *P. expansum* had grown 9 weeks. On right, stems in solutions on which no fungus had been grown.

This study indicates that the fungus, *P. expansum*, produces in culture solution a toxic principle which is capable of causing wilting of cut stems of common Malva when placed in such solutions. A study of longitudinal sections of these wilted stems showed that the stain of the culture solution on which the fungus had grown had been carried up into the stems of the wilted plants a distance of 5 to 7 inches. *P. expansum* changes the color of the medium from an original clear liquor to a definitely dark amber color. The appearance of the stain in the tissues of the leafy plants some distance from the cut ends indicates that there had been no interference with the water conduction of the stem.

TOXICITY IN RELATION TO CAULIFLOWER PLANTS

In order to check up on the previous work, three liters of Czapek's modified nutrient solution were prepared according to the usual formula, adding 3½ per cent of dextrose in all cases. The stock was divided into the following portions, and autoclaved 10 minutes at 15 lbs. pressure:

9–200 c.c. lots at pH 4.4 in 500 c.c. flasks
5–100 c.c. lots at pH 4.4 in 250 c.c. flasks
5–100 c.c. lots at pH 7.0 in 250 c.c. flasks

Spores from pure cultures of *P. expansum* were planted on the 9–200 c.c. lots and the cultures incubated at room temperature (15–20° C.). Good growth resulted and the mats were strong and covered with green spores after the third day. After 16 days the solutions were decanted from the flasks and filtered by suction through a Buchner funnel, using double layers of filter paper and a heavy mass of absorbent cotton, previously moistened with distilled water. Careful microscopic observation of the filtrate indicated the absence of spores. This filtrate will be referred to in this paper as the "cultured" solution. Volumes of 100 c.c. of the "cultured" solu-

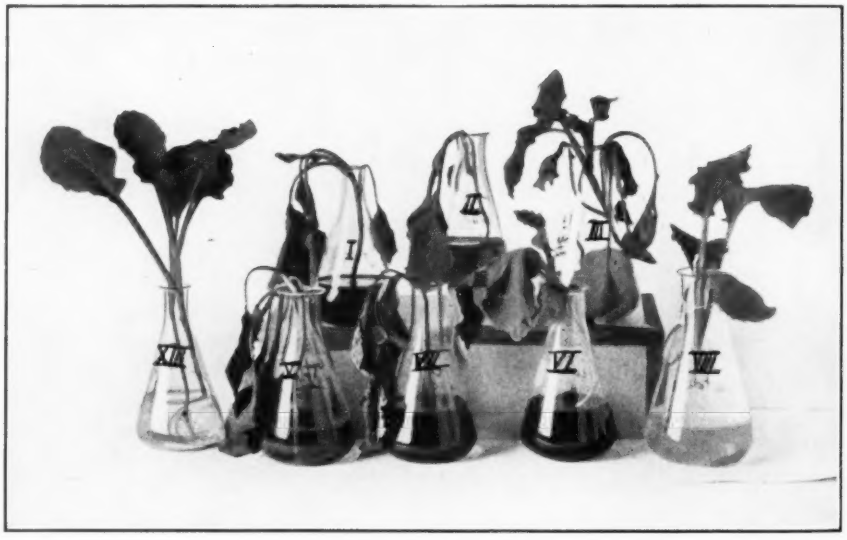


FIG. 2. Cauliflower plants in Czapek's solution for 68 hours. Numbers on flasks correspond to the numbers given the various solutions in table 1.

tion, the sterile solutions at different H-ion concentrations, tap water and distilled water were placed in 250 c.c. Erlenmeyer flasks and identified by number as shown in table 1.

TABLE 1.—*Solutions used in toxicity tests on cauliflower plants.*

No.	Condition of solution	No. & vol. in flasks	No. plants used
1	Cultured soln. filtered, unheated, pH 5.0	2–100 c.c.	2
2	Cultured soln. filtered, heated to boiling	"	3
3	Cultured soln. filtered, autoclaved 15 minutes	"	2
4	Cultured soln. filtered, unheated, plus toluol	"	2
5	Cultured soln. not heated, not filtered	"	2
6	Cultured soln. filtered, plus 1 c.c. N NaOH per 100 c.c. sol.	"	2
7	Cultured soln. filtered, plus 1 c.c. N/2 HCl per 100 c.c. sol.	"	2
8	Sterile Czapek soln. pH 4.4 no growth, no toluol	"	2
9	Sterile Czapek soln. pH 7.0 no growth, no toluol	"	2
10	Sterile Czapek soln. pH 4.4 no growth, toluol added	"	4
11	Sterile Czapek soln. pH 7.0 no growth, toluol added	"	4
12	Tap water, autoclaved, plus toluol	"	3
13	Tap water, unheated, no toluol	"	4
14	Tap water, boiled, no toluol	"	4
15	Distilled water, plus toluol	"	4
16	Distilled water, no toluol	"	4
17	150 c.c. "cultured" soln. filtered, plus 50 c.c. Dist. Water	"	4
18	Plants in dry flasks	2	5

Due to a scarcity of herbaceous plant material at this time, young cauliflower plants (*Brassica oleracea* var. *Botrytis*) grown 3 months in the open ground and not over 6 to 8 inches in height, were used in this experiment. The plants were pulled, washed free of soil and placed within 10 minutes after their removal from the soil in the flasks as indicated in table 1. After 18 hours the injurious effect of the toxic solutions was noted in a definite wilting of the plants which had their roots bathed in these cultured solutions. The presence of broken roots was negligible on account of soil conditions and care in pulling plants. Less toxicity was noted in the first 24 hours in the solution which had been autoclaved after the fungus had grown on it, but this delayed action was just as effective in producing wilting in the latter part of the experiment as was the more rapid action of the unheated "cultured" solution. (See figure 2.)

In the boiled "cultured" solution there was scarcely any less injury to the plants during the first few hours than in the unboiled "cultured" solution. However, the wilting was finally equally as pronounced in these two solutions and the leaves of all the plants were much drier and more brittle than the leaves on the plants in dry Erlemeyer flasks. The use of toluol was found to be unnecessary during these tests of short duration, the injurious effects on the tissues of the plants were found to more than offset any value in maintaining a condition of sterility in the solutions under test. All the plants kept in the various control solutions were in a growing condition at the conclusion of the experiment after 68 hours. (See table 2.)

TOXICITY IN RELATION TO GROWING ALFALFA STEMS

Growing stems of alfalfa, *Medicago sativa* L. were placed in some of the same test solutions used in the foregoing test, in the order shown in table 3.

TABLE 2.—*Condition of cauliflower plants at different times during toxicity tests.*

No. of Solution	After 18 hours	After 22 hours	After 43 hours	After 68 hours
1	Wilting	Wilting definite	Leaves dry	Leaves brittle
2	Slight wilting	Wilting definite	Leaves dry	Leaves brittle
3	No wilting	No wilting	Leaves limp	Leaves limp
4	Slight wilting	Wilting definite	Leaves dry	Leaves dry
5	Wilting	Wilting	Leaves dry & yellow	Leaves dry
6	Wilting	Wilting	Leaves limp	Leaves limp
7	Wilting	Wilting	Wilting definite	Leaves dry
8	No wilting	No wilting	No wilting	Plants growing
9	1 plant wilted 1 plant growing	1 wilted 1 growing	Plants recovered	Plants growing
10	No wilting	No wilting	No wilting	Plants growing
11	No wilting	No wilting	No wilting	Plants growing
12	No wilting	No wilting	No wilting	Plants growing
13	No wilting	No wilting	No wilting	Plants growing
14	No wilting	No wilting	No wilting	Plants growing
15	No wilting	No wilting	No wilting	Plants growing
16	No wilting	No wilting	No wilting	Plants growing
17	Wilting definite	Wilting definite	Wilted badly	Leaves dry
18	Wilting definite	Wilting definite	Wilted badly	Leaves dry, not brittle

TABLE 3.—*Solutions used in toxicity tests on alfalfa stems.*

No.	Condition of solution	No. & vol. in flasks	No. plants used
1	"Cultured" soln. filtered, unheated pH 5.0	2–100 c.c.	2
2	"Cultured" soln. filtered, boiled 1 min.	2–100 c.c.	3
3	"Cultured" soln. filtered, autoclaved 15 min.	2–100 c.c.	2
5	"Cultured" soln. not filtered, not heated	2–100 c.c.	2
6	"Cultured" soln. filtered, plus 1 c.c. N NaOH	2–100 c.c.	2
7	"Cultured" soln. filtered, plus 1 c.c. N/2 HCl	2–100 c.c.	2
8	Sterile fresh culture soln. pH 4.40	2–100 c.c.	2
9	Sterile fresh culture soln. pH 7.00	2–100 c.c.	2
13	Cold tap water	2–100 c.c.	2
14	Autoclaved tap water	2–100 c.c.	2
16	Distilled water	2–100 c.c.	2
17	150 c.c. "cultured" soln. plus 50 c.c. water	2–100 c.c.	4
18	No solution in flasks, air dry	2	5

After 2 hours in these test solutions, wilting was apparent in sets numbered 1, 2, 3, 5, 6, 17 and 18 in equal amounts in all cases. After 20 hours the same conditions existed, except that the greatest amount of wilting had occurred in No. 3 and in one plant in No. 2. After 48 hours at room temperature, the wilting had progressed in all the "cultured" solutions, both boiled and autoclaved, acid and alkali treated and diluted, to such an extent that the leaves on the stems were dried entirely and were more brittle than those on the stems in the empty flasks without water. After 4 days time all stems were dry except those in the sterile fresh culture solution.

The results of these experiments indicate that a toxic principle is produced in the culture solution upon which *P. expansum* has grown, and that this product of fungus growth is capable of causing wilting in certain herbaceous plants, whether absorbed through the cut ends of the stem or through the roots of the growing plants. This principle has proved to be thermostable and non-volatile, as was determined by Fahmy for the toxic principle produced by *F. solani*.

This work indicates that the production of a wilt-inducing principle in culture solutions is not limited to plant pathogens such as *Fusarium sp.*, but that a saprophytic fungus like Penicillium may act in a similar manner.

DIVISION OF PLANT PATHOLOGY,
UNIVERSITY OF CALIFORNIA.

REFERENCES CITED

(1) FAHMY, T. The production by Fusarium solani of a toxic excretory substance capable of causing wilting in plants. Phytopathology **13**: 543–550. Dec., 1923.

(2) HASKELL, R. J. Fusarium wilt of potato in the Hudson River Valley, New York. Phytopathology **9**: 223–260. June, 1919. Literature cited, p. 259–260.

PHYTOPATHOLOGICAL NOTES

Infection produced by the spores of Ustilago striaeformis (Westd.) Niessl.—The writer has experienced difficulty in infecting timothy with germinated spores of *Ustilago striaeformis* from timothy. Preliminary results point to seedling infection as a good percentage in one lot of inoculated plantlets show infection after three months while the checks are not infected. Investigations are now under way to verify this preliminary experiment and complete the problem.—W. H. Davis.

National Southeastern University of Nanking, China.—On the 12th of December, 1923, the main building of the College of Agriculture of the National Southeastern University of Nanking, China, was destroyed by fire. Practically all of their library dealing with the Entomology and Plant Pathology was destroyed. The work in Plant Pathology was just getting well under way in this Institution. This disaster will greatly handicap the work there. An appeal has been made to me by Professor F. L. Tai, of the Department of Plant Pathology, and by Professor G. P. Jung, of the Department of Entomology, asking for the assistance of their American colleagues in the matter of reprints, bulletins, etc., dealing with Plant Pathology and Entomology. I trust that the members of the American Phytopathological Society will each contribute whatever they can from their publications. Contributions should be mailed to either of the above-named professors or to Professor P. W. Tsou, Dean of the College of Agriculture there.—H. H. Whetzel.

Honors for Dr. A. Jaczewski.—The Mycological section of the Russian Botanical Society, the permanent Board of the Entomo-Phytopathological Congresses and the State Institute of Experimental Agronomy announce that on February 27, 1924, at 1 p. m. in the rooms of the Hale Institute of Experimental Agronomy (Petrograd, Morskaïa street, 42) was celebrated the thirty-fifth anniversary of the scientific activity of Professor A. Jaczewski. The order of the day consisted in the reading of telegrams and congratulations and in the offering of a special medal for remembrance of this day of anniversary.